



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

|   |  |   |   |
|---|--|---|---|
| (51) International Patent Classification <sup>6</sup> :<br><br>C07D 403/06, 403/14, 401/14, A61K 31/495   |  | A1  | (11) International Publication Number: <b>WO 98/06715</b><br><br>(43) International Publication Date: 19 February 1998 (19.02.98) |
| (21) International Application Number: PCT/US97/13873<br><br>(22) International Filing Date: 7 August 1997 (07.08.97)   |  | (81) Designated States: JP, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). |   |
| (30) Priority Data:<br>60/023,638 9 August 1996 (09.08.96) US   |  | Published<br><i>With international search report.</i>   |   |
| (71) Applicants (for all designated States except US): SMITHKLINE BEECHAM CORPORATION [US/US]; One Franklin Plaza, Philadelphia, PA 19103 (US). SMITHKLINE BEECHAM PLC [GB/GB]; Three New Horizons Court, Brentford, Middlesex TW8 9EP (GB).  |  |   |   |
| (72) Inventors; and<br>(75) Inventors/Applicants (for US only): ADAMS, Jerry, Leroy [US/US]; 611 Forest Road, Wayne, PA 19087 (US). BOEHM, Jeffrey, Charles [US/US]; 248 Anthony Road, King of Prussia, PA 19406 (US). CHAN, George, Wai-Kin [US/US]; 249 Wiltshire Road, Wynnewood, PA 19096 (US). RAHMAN, Shirley, K. [GB/GB]; Bishops Stortford, Hertfordshire (GB). |  |   |   |
| (74) Agents: DINNER, Dara, L. et al.; SmithKline Beecham Corporation, Corporate Intellectual Property, UW2220, 709 Swedeland Road, P.O. Box 1539, King of Prussia, PA 19406-0939 (US).  |  |   |   |

(54) Title: NOVEL PIPERAZINE CONTAINING COMPOUNDS

## (57) Abstract

Novel 3-Carboxyindole piperazine amide containing compounds, and compositions for use in therapy as anti-inflammatory agents, and inhibitors of cytokine p38/MAP kinase mediated diseases.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

|    |                          |    |                                       |    |   |    |                          |
|----|--------------------------|----|---------------------------------------|----|---|----|--------------------------|
| AL | Albania                  | ES | Spain                                 | LS | Lesotho                                   | SI | Slovenia                 |
| AM | Armenia                  | FI | Finland                               | LT | Lithuania                                 | SK | Slovakia                 |
| AT | Austria                  | FR | France                                | LU | Luxembourg                                | SN | Senegal                  |
| AU | Australia                | GA | Gabon                                 | LV | Latvia                                    | SZ | Swaziland                |
| AZ | Azerbaijan               | GB | United Kingdom                        | MC | Monaco                                    | TD | Chad                     |
| BA | Bosnia and Herzegovina   | GE | Georgia                               | MD | Republic of Moldova                       | TG | Togo                     |
| BB | Barbados                 | GH | Ghana                                 | MG | Madagascar                                | TJ | Tajikistan               |
| BE | Belgium                  | GN | Guinea                                | MK | The former Yugoslav Republic of Macedonia | TM | Turkmenistan             |
| BF | Burkina Faso             | GR | Greece                                | ML | Mali                                      | TR | Turkey                   |
| BG | Bulgaria                 | HU | Hungary                               | MN | Mongolia                                  | TT | Trinidad and Tobago      |
| BJ | Benin                    | IE | Ireland                               | MR | Mauritania                                | UA | Ukraine                  |
| BR | Brazil                   | IL | Israel                                | MW | Malawi                                    | UG | Uganda                   |
| BY | Belarus                  | IS | Iceland                               | NB | Niger                                     | US | United States of America |
| CA | Canada                   | IT | Italy                                 | NL | Netherlands                               | UZ | Uzbekistan               |
| CF | Central African Republic | JP | Japan                                 | NO | Norway                                    | VN | Viet Nam                 |
| CG | Congo                    | KE | Kenya                                 | NZ | New Zealand                               | YU | Yugoslavia               |
| CH | Switzerland              | KG | Kyrgyzstan                            | PL | Poland                                    | ZW | Zimbabwe                 |
| CI | Côte d'Ivoire            | KP | Democratic People's Republic of Korea | PT | Portugal                                  |    |                          |
| CM | Cameroon                 | KR | Republic of Korea                     | R  | Romania                                   |    |                          |
| CN | China                    | KZ | Kazakhstan                            | RU | Russian Federation                        |    |                          |
| CU | Cuba                     | LC | Saint Lucia                           | SD | Sudan                                     |    |                          |
| CZ | Czech Republic           | LI | Liechtenstein                         | SE | Sweden                                    |    |                          |
| DE | Germany                  | LK | Sri Lanka                             | SG | Singapore                                 |    |                          |
| DK | Denmark                  | LR | Liberia                               |    |   |    |                          |
| EE | Estonia                  |    |                                       |    |   |    |                          |

## NOVEL PIPERAZINE CONTAINING COMPOUNDS

### FIELD OF THE INVENTION

10 This invention relates to a novel group of indole containing compounds, processes for the preparation thereof, the use thereof in treating cytokine mediated diseases and pharmaceutical compositions for use in such therapy.

### BACKGROUND OF THE INVENTION

15 Interleukin-1 (IL-1) and Tumor Necrosis Factor (TNF) are biological substances produced by a variety of cells, such as monocytes or macrophages. IL-1 has been demonstrated to mediate a variety of biological activities thought to be important in immunoregulation and other physiological conditions such as inflammation [See, e.g., Dinarello et al., *Rev. Infect. Disease*, 6, 51 (1984)].

20 The myriad of known biological activities of IL-1 include the activation of T helper cells, induction of fever, stimulation of prostaglandin or collagenase production, neutrophil chemotaxis, induction of acute phase proteins and the suppression of plasma iron levels.

There are many disease states in which excessive or unregulated IL-1 production is implicated in exacerbating and/or causing the disease. These include rheumatoid arthritis, osteoarthritis, endotoxemia and/or toxic shock syndrome, other acute or chronic inflammatory disease states such as the inflammatory reaction induced by endotoxin or inflammatory bowel disease; tuberculosis, atherosclerosis, muscle degeneration, cachexia, psoriatic arthritis, 25 Reiter's syndrome, rheumatoid arthritis, gout, traumatic arthritis, rubella

arthritis, and acute synovitis. Recent evidence also links IL-1 activity to diabetes and pancreatic  $\beta$  cells.

Dinarello, J. Clinical Immunology, 5 (5), 287-297 (1985), reviews the biological activities which have been attributed to IL-1. It should be noted that 5 some of these effects have been described by others as indirect effects of IL-1.

Excessive or unregulated TNF production has been implicated in mediating or exacerbating a number of diseases including rheumatoid arthritis, 10 rheumatoid spondylitis, osteoarthritis, gouty arthritis and other arthritic conditions; sepsis, septic shock, endotoxic shock, gram negative sepsis, toxic shock syndrome, adult respiratory distress syndrome, cerebral malaria, chronic pulmonary inflammatory disease, silicosis, pulmonary sarcoidosis, bone resorption diseases, reperfusion injury, graft vs. host reaction, allograft rejections, fever and myalgias due to infection, such as influenza, cachexia secondary to infection or malignancy, cachexia, secondary to acquired immune 15 deficiency syndrome (AIDS), AIDS, ARC (AIDS related complex), keloid formation, scar tissue formation, Crohn's disease, ulcerative colitis, or pyresis.

AIDS results from the infection of T lymphocytes with Human Immunodeficiency Virus (HIV). At least three types or strains of HIV have been identified, i.e., HIV-1, HIV-2 and HIV-3. As a consequence of HIV 20 infection, T-cell mediated immunity is impaired and infected individuals manifest severe opportunistic infections and/or unusual neoplasms. HIV entry into the T lymphocyte requires T lymphocyte activation. Other viruses, such as HIV-1, HIV-2 infect T lymphocytes after T Cell activation and such virus protein expression and/or replication is mediated or maintained by such T cell 25 activation. Once an activated T lymphocyte is infected with HIV, the T lymphocyte must continue to be maintained in an activated state to permit HIV gene expression and/or HIV replication. Monokines, specifically TNF, are implicated in activated T-cell mediated HIV protein expression and/or virus replication by playing a role in maintaining T lymphocyte activation.

30 Therefore, interference with monokine activity such as by inhibition of monokine production, notably TNF, in an HIV-infected individual aids in

limiting the maintenance of T cell activation, thereby reducing the progression of HIV infectivity to previously uninfected cells which results in a slowing or elimination of the progression of immune dysfunction caused by HIV infection. Monocytes, macrophages, and related cells, such as kupffer and glial cells, have  
5 also been implicated in maintenance of the HIV infection. These cells, like T-cells, are targets for viral replication and the level of viral replication is dependent upon the activation state of the cells. [See Rosenberg *et al.*, The Immunopathogenesis of HIV Infection, Advances in Immunology, Vol. 57, (1989)]. Monokines, such as TNF, have been shown to activate HIV replication  
10 in monocytes and/or macrophages [See Poli, *et al.*, Proc. Natl. Acad. Sci., 87:782-784 (1990)], therefore, inhibition of monokine production or activity aids in limiting HIV progression as stated above for T-cells.

TNF has also been implicated in various roles with other viral infections, such as the cytomegalia virus (CMV), influenza virus, and the herpes  
15 virus for similar reasons as those noted.

Interleukin-8 (IL-8) is a chemotactic factor first identified and characterized in 1987. IL-8 is produced by several cell types including mononuclear cells, fibroblasts, endothelial cells, and keratinocytes. Its production from endothelial cells is induced by IL-1, TNF, or  
20 lipopolysachharide (LPS). Human IL-8 has been shown to act on Mouse, Guinea Pig, Rat, and Rabbit Neutrophils. Many different names have been applied to IL-8, such as neutrophil attractant/activation protein-1 (NAP-1), monocyte derived neutrophil chemotactic factor (MDNCF), neutrophil activating factor (NAF), and T-cell lymphocyte chemotactic factor.

IL-8 stimulates a number of functions in vitro. It has been shown to have chemoattractant properties for neutrophils, T-lymphocytes, and basophils. In addition it induces histamine release from basophils from both normal and atopic individuals as well as lysozomal enzyme release and respiratory burst from neutrophils. IL-8 has also been shown to increase the surface expression  
25 of Mac-1 (CD11b/CD18) on neutrophils without de novo protein synthesis, this may contribute to increased adhesion of the neutrophils to vascular endothelial

cells. Many diseases are characterized by massive neutrophil infiltration. Conditions associated with an increased in IL-8 production (which is responsible for chemotaxis of neutrophil into the inflammatory site) would benefit by compounds which are suppressive of IL-8 production.

5       IL-1 and TNF affect a wide variety of cells and tissues and these cytokines as well as other leukocyte derived cytokines are important and critical inflammatory mediators of a wide variety of disease states and conditions. The inhibition of these cytokines is of benefit in controlling, reducing and alleviating many of these disease states.

10      There remains a need for treatment, in this field, for compounds which are cytokine suppressive anti-inflammatory drugs, i.e. compounds which are capable of inhibiting cytokines, such as IL-1, IL-6, IL-8 and TNF.

### SUMMARY OF THE INVENTION

15      This invention relates to the novel compounds of Formula (I) or (II) and pharmaceutical compositions comprising a compound of Formula (I) or (II) and a pharmaceutically acceptable diluent or carrier.

This invention also relates to a method of inhibiting cytokines and the treatment of a cytokine mediated disease, in a mammal in need thereof, which  
20      comprises administering to said mammal an effective amount of a compound of Formula (I) or (II).

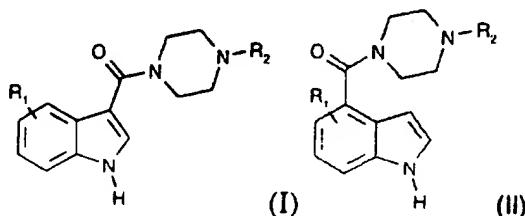
In particular the present invention relates to a method of treating a CSBP/RK/p38 kinase mediated disease, in a mammal in need thereof.

This invention more specifically relates to a method of inhibiting the  
25      production of IL-1 in a mammal in need thereof which comprises administering to said mammal an effective amount of a compound of Formula (I) or (II).

This invention more specifically relates to a method of inhibiting the production of IL-8 in a mammal in need thereof which comprises administering to said mammal an effective amount of a compound of Formula (I) or (II).

This invention more specifically relates to a method of inhibiting the production of TNF in a mammal in need thereof which comprises administering to said mammal an effective amount of a compound of Formula (I) or (II).

Accordingly, the present invention provides for a compound of Formula 5 (I) or Formula (II):



wherein

- $R_1$  is hydrogen, alkyl, aryl, heteroaryl, aryloxy, heteroaryloxy, nitro, amino, 10 cyano, carboxy, carboxyalkoxy, carboxamido, or halogen, wherein the aryl, heteroaryl, heteroaryloxy, or aryloxy moieties may be optionally substituted; and
- $R_2$  is aryl, heteroaryl, arylalkyl, heteroarylalkyl, alkyl, cycloalkyl, or cycloalkyl 15 alkyl, and wherein all of these moieties may be optionally substituted; or a pharmaceutically acceptable salt thereof.

#### DETAILED DESCRIPTION OF THE INVENTION

In compounds of Formula (I) or (II)  $R_1$  is suitably hydrogen, alkyl, aryl, heteroaryl, aryloxy, heteroaryloxy, nitro, amino, cyano, carboxy, 20 carboxyalkoxy, carboxamido, or halogen, wherein the aryl, heteroaryl, heteroaryloxy, or aryloxy moieties may be optionally substituted one to three times independently by halogen; haloalkyl (such as  $CF_3$ ); alkyl; cyano; carboxy, carboxyalkoxy, carboxamido, nitro; alkoxy; hydroxy; amino; mono- or di-substituted alkyl amino; or  $S(O)m$  alkyl, wherein  $m$  is 0, 1 or 2, such as 25 methyl thio, methylsulfinyl or methyl sulfonyl. Preferably the  $R_1$  moiety is in the 5-position of the indole ring. The aryl, heteroaryl, aryloxy, heteroaryloxy moiety may be optionally substituted one or more times as defined herein.

When R<sub>1</sub> is aryl it is preferably phenyl; when R<sub>1</sub> is aryloxy it is preferably benzyloxy.

In compounds of Formula (I) or (II) R<sub>2</sub> is suitably aryl, heteroaryl, arylalkyl, heteroarylalkyl, alkyl, cycloalkyl, or a cycloalkyl alkyl group. Each

5 of these moieties may be optionally substituted one or more times independently by halogen; haloalkyl (such as CF<sub>3</sub>); alkyl; cyano; carboxy, carboxyalkoxy, carboxamido, nitro; alkoxy; hydroxy; amino; mono- or di-substituted alkyl amino; or S(O)<sub>m</sub> alkyl, wherein m is 0, 1 or 2, such as methyl thio, methylsulfinyl or methyl sulfonyl.

10 Preferably when R<sub>2</sub> is aryl it is a phenyl moiety, when R<sub>2</sub> is an arylalkyl group it is preferably benzyl, phenethyl or naphthylmethyl. Preferably when R<sub>2</sub> is a heteroaryl or heteroarylalkyl, it is a pyridyl, or pyrimidine group. The alkyl moiety in the aryl alkyl group may also be optionally substituted, such as by halogen, hydroxy, alkoxy, alkyl, aryl, heteroaryl, arylalkyl, or heteroarylalkyl, groups.

15 As used herein, "optionally substituted" unless specifically defined shall mean such groups as halogen, such as fluorine, chlorine, bromine or iodine; hydroxy; hydroxy substituted C<sub>1</sub>-10alkyl; C<sub>1</sub>-10 alkoxy, such as methoxy or ethoxy; cyano; carboxy, carboxyalkoxy, carboxamido, S(O)<sub>m</sub> alkyl, wherein m is 0, 1 or 2, such as methyl thio, methylsulfinyl or methyl sulfonyl; amino, mono & di-alkyl substituted amino; C<sub>1</sub>-10 alkyl, cycloalkyl, or cycloalkyl alkyl group, such as methyl, ethyl, propyl, isopropyl, t-butyl, etc. or cyclopropyl methyl; halosubstituted C<sub>1</sub>-10 alkyl, such CF<sub>3</sub>; an optionally substituted heteroaryl, aryl, such as phenyl, or an optionally substituted heteroarylalkyl, 20 arylalkyl, such as benzyl or phenethyl, wherein these aryl moieties may also be substituted one or more times by halogen; hydroxy; hydroxy substituted alkyl; C<sub>1</sub>-10 alkoxy; cyano; carboxy, carboxyalkoxy, carboxamido, S(O)<sub>m</sub> alkyl; amino, mono & di-alkyl substituted amino; alkyl, or halo substituted alkyl, such as CF<sub>3</sub>.

Suitable pharmaceutically acceptable salts are well known to those skilled in the art and include basic salts of inorganic and organic acids, such as hydrochloric acid, hydrobromic acid, sulphuric acid, phosphoric acid, methane sulphonic acid, ethane sulphonic acid, acetic acid, malic acid, tartaric acid, citric acid, lactic acid, oxalic acid, succinic acid, fumaric acid, maleic acid, benzoic acid, salicylic acid, phenylacetic acid and mandelic acid. In addition, pharmaceutically acceptable salts of compounds of Formula (I) may also be formed with a pharmaceutically acceptable cation, for instance, if a substituent group comprises a carboxy moiety. Suitable pharmaceutically acceptable cations are well known to those skilled in the art and include alkaline, alkaline earth, ammonium and quaternary ammonium cations.

The following terms, as used herein, refer to:

- "halo" or "halogens", include the halogens: chloro, fluoro, bromo and iodo.
- "C<sub>1-10</sub>alkyl" or "alkyl" - both straight and branched chain radicals of 1 to 10 carbon atoms, unless the chain length is otherwise limited, including, but not limited to, methyl, ethyl, *n*-propyl, *iso*-propyl, *n*-butyl, *sec*-butyl, *iso*-butyl, *tert*-butyl, *n*-pentyl and the like.
- "aryl" - phenyl and naphthyl.
- "cycloalkyl" is used herein to mean cyclic radicals, preferably of 3 to 8 carbons, including but not limited to cyclopropyl, cyclopentyl, cyclohexyl, and the like.
- "heteroaryl" (on its own or in any combination, such as "heteroaryloxy", or "heteroaryl alkyl") - a 5-10 membered aromatic ring system in which one or more rings contain one or more heteroatoms selected from the group consisting of N, O or S, such as, but not limited, to pyrrole, pyrazole, furan, thiophene, quinoline, isoquinoline, quinazolinyl, pyridine, pyrimidine, oxazole, thiazole, thiadiazole, triazole, imidazole, or benzimidazole.
- "heterocyclic" (on its own or in any combination, such as "heterocyclalkyl") - a saturated or partially unsaturated 4-10 membered ring

system in which one or more rings contain one or more heteroatoms selected from the group consisting of N, O, or S; such as, but not limited to, pyrrolidine, piperidine, piperazine, morpholine, tetrahydro pyran, or imidazolidine.

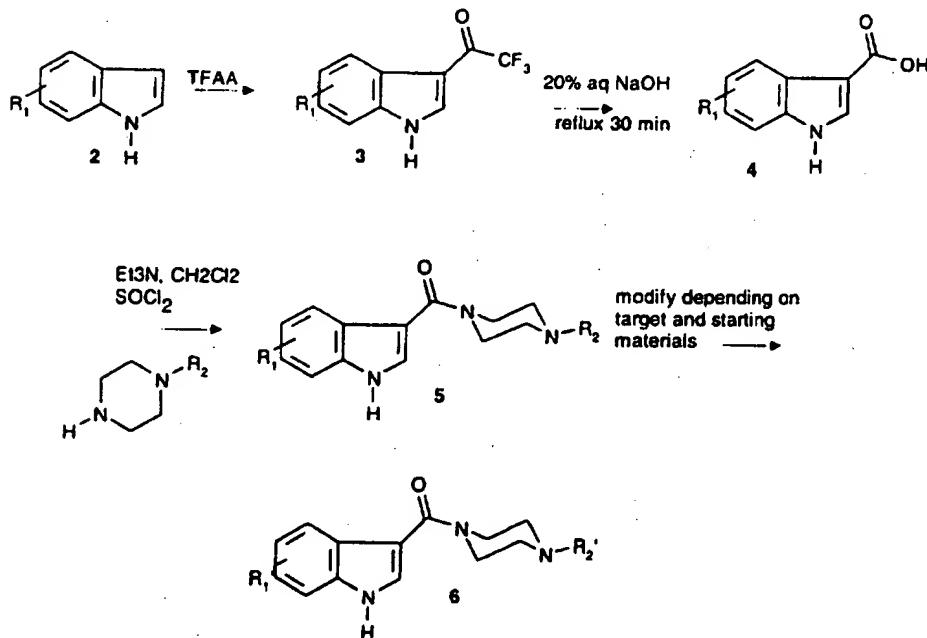
- The term "aralkyl" or "heteroarylalkyl" or "heterocyclicalkyl" is used  
5 herein to mean C<sub>1</sub>-4 alkyl as defined above attached to an aryl, heteroaryl or heterocyclic moiety as also defined herein unless otherwise indicate.
  - "sulfinyl" - the oxide S (O) of the corresponding sulfide, the term "thio" refers to the sulfide, and the term "sulfonyl" refers to the fully oxidized S (O)<sub>2</sub> moiety.
- 10 Exemplified compounds of Formula (I) include:
  - 1-(1H-Indol-3-ylcarbonyl)-4-(benzyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(phenyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(2-pyridinyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(2-pyrimidinyl)piperazine
- 15
  - 1-(1H-Indol-3-ylcarbonyl)-4-(diphenylmethyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(4-pyridinylmethyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(4-trifluoromethylphenylmethyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(4-fluorophenylmethyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(methyl)piperazine
- 20
  - 1-(1H-Indol-3-ylcarbonyl)-4-(cyclohexyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(cyclopropylmethyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(4-methylbenzyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(4-cyanobenzyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(2-naphthyl)piperazine
- 25
  - 1-(1H-Indol-3-ylcarbonyl)-4-(2-phenylethyl)piperazine
  - 1-(1H-Indol-3-ylcarbonyl)-4-(4-methoxybenzyl)piperazine
  - 1-(1H-5-Bromoindol-3-ylcarbonyl)-4-(benzyl)piperazine
  - 1-(1H-5-Methylindol-3-ylcarbonyl)-4-(benzyl)piperazine
  - 1-(1H-5-Chloroindol-3-ylcarbonyl)-4-(benzyl)piperazine
- 30
  - 1-(1H-5-Benzylxyindol-3-ylcarbonyl)-4-(benzyl)piperazine
  - 1-(1H-5-Nitroindol-3-ylcarbonyl)-4-(benzyl)piperazine
  - 1-(1H-5-Fluoroindol-3-ylcarbonyl)-4-(benzyl)piperazine

1-(1H-5-Aminoindol-3-ylcarbonyl)-4-(benzyl)piperazine

1-(1H-5-Phenylindol-3-ylcarbonyl)-4-(benzyl)piperazine

The compounds of Formula (I) or (II) may be obtained by applying  
 5 synthetic procedures, some of which are illustrated in Schemes I, etc., herein.  
 The synthesis provided for in these Schemes is applicable for the producing  
 compounds of Formula (I) or (II) having a variety of different R<sub>1</sub> and R<sub>2</sub> groups  
 which are reacted, employing optional substituents which are suitably protected,  
 to achieve compatibility with the reactions outlined herein. Subsequent  
 10 deprotection, in those cases, then affords compounds of the nature generally  
 disclosed. Once the nucleus has been established, further compounds of  
 Formula (I) or (II) may be prepared by applying standard techniques for  
 functional group interconversion, well known in the art.

Scheme 1 - General method.



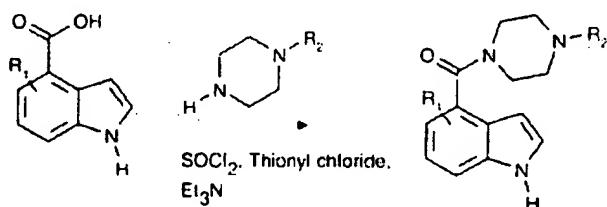
Substituted indole-3-carboxylic acids (Formula (I)) were obtained from  
 the appropriately substituted indole by the method of Katner [Katner, A. S.

*Organic Preps and Procs.* 1970, 2(4), 297 - 303] wherein the indole is reacted with trifluoroacetic anhydride (TFAA) in THF or DMF to afford the 3-trifluoroacetyl indole **3** (Scheme 1). The trifluoroacetyl indoles are then hydrolyzed under vigorous alkaline conditions to the acids **4**. Piperazinyl amides **5** are rapidly and conveniently prepared by reacting the amine and carboxylic acid **4** utilizing thionyl chloride as the coupling agent. Additional analogs are obtained in some cases by further modification of R<sub>1</sub> and R<sub>2</sub> after amide formation.

Indole-4-carboxylic acids (Formula (II)) are prepared in a similar manner, see Scheme 2 below.

10

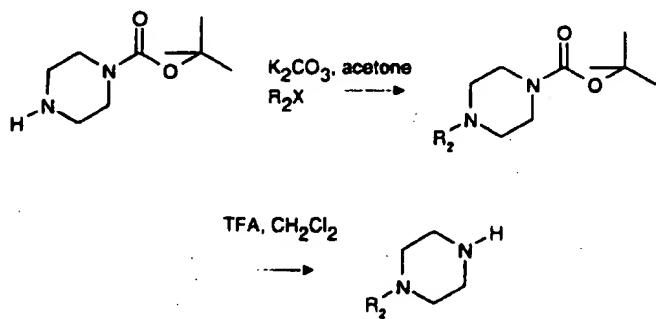
Scheme 2 - Indole 4-carboxamides.



Piperazines which were not commercially available were prepared from 4-BOC-piperazine by reaction of the secondary amine with electrophiles and subsequent removal of the BOC protecting group with TFA (Scheme 3).

15

Scheme 3 - Preparation of substituted piperazines.



Suitable protecting groups for use with hydroxyl, etc. are well known in the art and described in many references, for instance, Protecting Groups in Organic Synthesis, Greene T W, Wiley-Interscience, New York, 1981. Suitable examples of hydroxyl protecting groups include silyl ethers, such as t-

5 butyldimethyl or t-butyldiphenyl, and alkyl ethers, such as methyl connected by an alkyl chain of variable link,  $(CR_{10}R_{20})_n$ .

Pharmaceutically acid addition salts of compounds of Formula (I) or (II) may be obtained in known manner, for example by treatment thereof with an  
10 appropriate amount of acid in the presence of a suitable solvent.

#### METHODS OF TREATMENT

The compounds of Formula (I) or (II), or a pharmaceutically acceptable salt thereof can be used in the manufacture of a medicament for the prophylactic  
15 or therapeutic treatment of any disease state in a human, or other mammal, which is exacerbated or caused by excessive or unregulated cytokine production by such mammal's cell, such as but not limited to monocytes and/or macrophages.

20 Compounds of Formula (I) or (II) are capable of inhibiting proinflammatory cytokines, such as IL-1, IL-6, IL-8 and TNF and are therefore of use in therapy. IL-1, IL-6, IL-8 and TNF affect a wide variety of cells and tissues and these cytokines, as well as other leukocyte-derived cytokines, are important and critical inflammatory mediators of a wide variety of disease states  
25 and conditions. The inhibition of these pro-inflammatory cytokines is of benefit in controlling, reducing and alleviating many of these disease states.

Accordingly, the present invention provides a method of treating a cytokine-mediated disease which comprises administering an effective  
30 cytokine-interfering amount of a compound of Formula (I) or Formula (II) or a pharmaceutically acceptable salt thereof.

For purposes herein, the compounds of Formula (I) and (II) all have the same dosages, and formulations as that of Formula (I) are used interchangeably herewith.

5

Compounds of Formula (I) are capable of inhibiting inducible proinflammatory proteins, such as COX-2, also referred to by many other names such as prostaglandin endoperoxide synthase-2 (PGHS-2) and are therefore of use in therapy. These proinflammatory lipid mediators of the cyclooxygenase (CO) pathway are produced by the inducible COX-2 enzyme. Regulation, therefore of COX-2 which is responsible for the these products derived from arachidonic acid, such as prostaglandins affect a wide variety of cells and tissues are important and critical inflammatory mediators of a wide variety of disease states and conditions. Expression of COX-1 is not effected by compounds of Formula (I). This selective inhibition of COX-2 may alleviate or spare ulcerogenic liability associated with inhibition of COX-1 thereby inhibiting prostoglandins essential for cytoprotective effects. Thus inhibition of these pro-inflammatory mediators is of benefit in controlling, reducing and alleviating many of these disease states. Most notably these inflammatory mediators, in particular prostaglandins, have been implicated in pain, such as in the sensitization of pain receptors, or edema. This aspect of pain management therefore includes treatment of neuromuscular pain, headache, cancer pain, and arthritis pain. Compounds of Formula (I) or a pharmaceutically acceptable salt thereof, are of use in the prophylaxis or therapy in a human, or other mammal, by inhibition of the synthesis of the COX-2 enzyme.

Accordingly, the present invention provides a method of inhibiting the synthesis of COX-2 which comprises administering an effective amount of a compound of Formula (I) or a pharmaceutically acceptable salt thereof. The present invention also provides for a method of prophylaxis treatment in a human, or other mammal, by inhibition of the synthesis of the COX-2 enzyme.

A new member of the MAP kinase family, alternatively termed CSBP, p38, or RK, has been identified independently by several laboratories recently. Activation of this novel protein kinase via dual phosphorylation has been observed in different cell systems upon stimulation by a wide spectrum of stimuli, such as physicochemical stress and treatment with lipopolysaccharide or proinflammatory cytokines such as interleukin-1 and tumor necrosis factor. The cytokine biosynthesis inhibitors, of the present invention, compounds of Formula (I), have been determined to be potent and selective inhibitors of CSBP/p38/RK kinase activity. These inhibitors are of aid in determining the signaling pathways involvement in inflammatory responses. In particular, for the first time a definitive signal transduction pathway can be prescribed to the action of lipopolysaccharide in cytokine production in macrophages.

The cytokine inhibitors were subsequently tested in a number of animal models for anti-inflammatory activity. Model systems were chosen that were relatively insensitive to cyclooxygenase inhibitors in order to reveal the unique activities of cytokine suppressive agents. The inhibitors exhibited significant activity in many such *in vivo* studies. Most notable are its effectiveness in the collagen-induced arthritis model and inhibition of TNF production in the endotoxic shock model. In the latter study, the reduction in plasma level of TNF correlated with survival and protection from endotoxic shock related mortality. Also of great importance are the compounds effectiveness in inhibiting bone resorption in a rat fetal long bone organ culture system.

Griswold et al., (1988) *Arthritis Rheum.* **31:**1406-1412; Badger, et al., (1989) *Circ. Shock* **27**, 51-61; Votta et al., (1994) *in vitro. Bone* **15**, 533-538; Lee et al., (1993). *B Ann. N. Y. Acad. Sci.* **696**, 149-170.

Another aspect of the present invention, therefore, is the treatment of a CSBP/RK/p38 kinase mediated disease, in a mammal in need thereof, which comprises administering to said mammal an effective amount of a compound of Formula (I). Suitable diseases, include those mentioned herein for IL-1, IL-6,

IL-8 and TNF and more specifically those disease which are CSBP/RK/p38 kinase mediated diseases. These include, but are not limited to rheumatoid arthritis, rheumatoid spondylitis, osteoarthritis, gouty arthritis and other arthritic conditions, sepsis, septic shock, endotoxic shock, gram negative sepsis, toxic shock syndrome, asthma, adult respiratory distress syndrome, stroke, reperfusion injury, CNS injuries, such as neurotrauma and ischemia, including both open and closed head injuries), psoriasis, restenosis, such as occurs following coronary angioplasty, cerebral malaria, chronic pulmonary inflammatory disease, silicosis, pulmonary sarcososis, bone resorption diseases, 10 osteoporosis, , graft vs. host reaction, allograft rejections, Crohn's disease, ulcerative colitis or any other anti-inflammatory bowel disease (IBD), or pyresis.

CNS injuries as defined herein include both open or penetrating head trauma, such as by surgery, or a closed head trauma injury, such as by an injury 15 to the head region. Also included within this definition is ischemic stroke, particularly to the brain area.

Ischemic stroke may be defined as a focal neurologic disorder that results from insufficient blood supply to a particular brain area, usually as a consequence of an embolus, thrombi, or local atheromatous closure of the blood 20 vessel. The role of inflammatory cytokines in this are has been emerging and the present invention provides a mean for the potential treatment of these injuries. Relatively little treatment, for an acute injury such as these has been available.

TNF- $\alpha$  is a cytokine with proinflammatory actions, including 25 endothelial leukocyte adhesion molecule expression. Leukocytes infiltrate into ischemic brain lesions and hence compounds which inhibit or decrease levels of TNF would be useful for treatment of ischemic brain injury. See Liu et al., Stoke, Vol. 25., No. 7, pp 1481-88 (1994) whose disclosure is incorporated herein by reference.

30 Models of closed head injuries and treatment with mixed 5-LO/CO agents is discussed in Shohami et al., J. of Vaisc & Clinical Physiology and

Pharmacology, Vol. 3, No. 2, pp. 99-107 (1992) whose disclosure is incorporated herein by reference. Treatment which reduced edema formation was found to improve functional outcome in those animals treated.

5 In particular, compounds of Formula (I) or a pharmaceutically acceptable salt thereof are of use in the prophylaxis or therapy of any disease state in a human, or other mammal, which is exacerbated by or caused by excessive or unregulated IL-1, IL-8 or TNF production by such mammal's cell, such as, but not limited to, monocytes and/or macrophages.

10

Accordingly, in another aspect, this invention relates to a method of inhibiting the production of IL-1 in a mammal in need thereof which comprises administering to said mammal an effective amount of a compound of Formula (I) or a pharmaceutically acceptable salt thereof.

15 There are many disease states in which excessive or unregulated IL-1 production is implicated in exacerbating and/or causing the disease. These include rheumatoid arthritis, osteoarthritis, stroke, endotoxemia and/or toxic shock syndrome, other acute or chronic inflammatory disease states such as the inflammatory reaction induced by endotoxin or inflammatory bowel disease,

20 tuberculosis, atherosclerosis, muscle degeneration, multiple sclerosis, cachexia, bone resorption, psoriatic arthritis, Reiter's syndrome, rheumatoid arthritis, gout, traumatic arthritis, rubella arthritis and acute synovitis. Recent evidence also links IL-1 activity to diabetes, pancreatic  $\beta$  cells and Alzheimer's disease.

In a further aspect, this invention relates to a method of inhibiting the  
25 production of TNF in a mammal in need thereof which comprises administering to said mammal an effective amount of a compound of Formula (I) or a pharmaceutically acceptable salt thereof.

Excessive or unregulated TNF production has been implicated in  
mediating or exacerbating a number of diseases including rheumatoid arthritis,  
30 rheumatoid spondylitis, osteoarthritis, gouty arthritis and other arthritic conditions, sepsis, septic shock, endotoxic shock, gram negative sepsis, toxic

shock syndrome, adult respiratory distress syndrome, stroke, cerebral malaria, chronic pulmonary inflammatory disease, silicosis, pulmonary sarcoidosis, bone resorption diseases, such as osteoporosis, reperfusion injury, graft vs. host reaction, allograft rejections, fever and myalgias due to infection, such as

5 influenza, cachexia secondary to infection or malignancy, cachexia secondary to acquired immune deficiency syndrome (AIDS), AIDS, ARC (AIDS related complex), keloid formation, scar tissue formation, Crohn's disease, ulcerative colitis and pyresis.

Compounds of Formula (I) are also useful in the treatment of viral infections, where such viruses are sensitive to upregulation by TNF or will elicit TNF production *in vivo*. The viruses contemplated for treatment herein are those that produce TNF as a result of infection, or those which are sensitive to inhibition, such as by decreased replication, directly or indirectly, by the TNF inhibiting-compounds of Formula (I). Such viruses include, but are not limited

10 to HIV-1, HIV-2 and HIV-3, Cytomegalovirus (CMV), Influenza, adenovirus and the Herpes group of viruses, such as but not limited to, Herpes Zoster and Herpes Simplex. Accordingly, in a further aspect, this invention relates to a method of treating a mammal afflicted with a human immunodeficiency virus (HIV) which comprises administering to such mammal an effective TNF

15 inhibiting amount of a compound of Formula (I) or a pharmaceutically acceptable salt thereof.

Compounds of Formula (I) may also be used in association with the veterinary treatment of mammals, other than in humans, in need of inhibition of TNF production. TNF mediated diseases for treatment, therapeutically or prophylactically, in animals include disease states such as those noted above, but in particular viral infections. Examples of such viruses include, but are not limited to, lentivirus infections such as, equine infectious anaemia virus, caprine arthritis virus, visna virus, or maedi virus or retrovirus infections, such as but not limited to feline immunodeficiency virus (FIV), bovine immunodeficiency

20 virus, or canine immunodeficiency virus or other retroviral infections.

The compounds of Formula (I) may also be used topically in the treatment or prophylaxis of topical disease states mediated by or exacerbated by excessive cytokine production, such as by IL-1 or TNF respectively, such as inflamed joints, eczema, psoriasis and other inflammatory skin conditions such 5 as sunburn; inflammatory eye conditions including conjunctivitis; pyresis, pain and other conditions associated with inflammation.

Compounds of Formula (I) have also been shown to inhibit the production of IL-8 (Interleukin-8, NAP). Accordingly, in a further aspect, this invention relates to a method of inhibiting the production of IL-8 in a mammal 10 in need thereof which comprises administering to said mammal an effective amount of a compound of Formula (I) or a pharmaceutically acceptable salt thereof.

There are many disease states in which excessive or unregulated IL-8 production is implicated in exacerbating and/or causing the disease. These 15 diseases are characterized by massive neutrophil infiltration such as, psoriasis, inflammatory bowel disease, asthma, cardiac and renal reperfusion injury, adult respiratory distress syndrome, thrombosis and glomerulonephritis. All of these diseases are associated with increased IL-8 production which is responsible for the chemotaxis of neutrophils into the inflammatory site. In contrast to other 20 inflammatory cytokines (IL-1, TNF, and IL-6), IL-8 has the unique property of promoting neutrophil chemotaxis and activation. Therefore, the inhibition of IL-8 production would lead to a direct reduction in the neutrophil infiltration.

The compounds of Formula (I) are administered in an amount sufficient to inhibit cytokine, in particular IL-1, IL-6, IL-8 or TNF, production such that it 25 is regulated down to normal levels, or in some case to subnormal levels, so as to ameliorate or prevent the disease state. Abnormal levels of IL-1, IL-6, IL-8 or TNF, for instance in the context of the present invention, constitute: (i) levels of free (not cell bound) IL-1, IL-6, IL-8 or TNF greater than or equal to 1 picogram per ml; (ii) any cell associated IL-1, IL-6, IL-8 or TNF; or (iii) the 30 presence of IL-1, IL-6, IL-8 or TNF mRNA above basal levels in cells or tissues in which IL-1, IL-6, IL-8 or TNF, respectively, is produced.

The discovery that the compounds of Formula (I) are inhibitors of cytokines, specifically IL-1, IL-6, IL-8 and TNF is based upon the effects of the compounds of Formulas (I) on the production of the IL-1, IL-8 and TNF in *in vitro* assays which are described herein.

5 As used herein, the term "inhibiting the production of IL-1 (IL-6, IL-8 or

TNF)" refers to:

a) a decrease of excessive *in vivo* levels of the cytokine (IL-1, IL-6, IL-8 or TNF) in a human to normal or sub-normal levels by inhibition of the *in vivo* release of the cytokine by all cells, including but not limited to monocytes

10 or macrophages;

b) a down regulation, at the genomic level, of excessive *in vivo* levels of the cytokine (IL-1, IL-6, IL-8 or TNF) in a human to normal or sub-normal levels;

c) a down regulation, by inhibition of the direct synthesis of the cytokine  
15 (IL-1, IL-6, IL-8 or TNF) as a posttranslational event; or

d) a down regulation, at the translational level, of excessive *in vivo* levels of the cytokine (IL-1, IL-6, IL-8 or TNF) in a human to normal or sub-normal levels.

20 As used herein, the term "TNF mediated disease or disease state" refers to any and all disease states in which TNF plays a role, either by production of TNF itself, or by TNF causing another monokine to be released, such as but not limited to IL-1, IL-6 or IL-8. A disease state in which, for instance, IL-1 is a major component, and whose production or action, is exacerbated or secreted in  
25 response to TNF, would therefore be considered a disease state mediated by TNF.

As used herein, the term "cytokine" refers to any secreted polypeptide  
30 that affects the functions of cells and is a molecule which modulates interactions between cells in the immune, inflammatory or hematopoietic response. A cytokine includes, but is not limited to, monokines and lymphokines, regardless of which cells produce them. For instance, a monokine

is generally referred to as being produced and secreted by a mononuclear cell, such as a macrophage and/or monocyte. Many other cells however also produce monokines, such as natural killer cells, fibroblasts, basophils, neutrophils, endothelial cells, brain astrocytes, bone marrow stromal cells, 5 epidermal keratinocytes and B-lymphocytes. Lymphokines are generally referred to as being produced by lymphocyte cells. Examples of cytokines include, but are not limited to, Interleukin-1 (IL-1), Interleukin-6 (IL-6), Interleukin-8 (IL-8), Tumor Necrosis Factor-alpha (TNF- $\alpha$ ) and Tumor Necrosis Factor beta (TNF- $\beta$ ).

10 As used herein, the term "cytokine interfering" or "cytokine suppressive amount" refers to an effective amount of a compound of Formula (I) which will cause a decrease in the *in vivo* levels of the cytokine to normal or sub-normal levels, when given to a patient for the prophylaxis or treatment of a disease state which is exacerbated by, or caused by, excessive or unregulated cytokine production.

15 As used herein, the cytokine referred to in the phrase "inhibition of a cytokine, for use in the treatment of a HIV-infected human" is a cytokine which is implicated in (a) the initiation and/or maintenance of T cell activation and/or activated T cell-mediated HIV gene expression and/or replication and/or (b) any 20 cytokine-mediated disease associated problem such as cachexia or muscle degeneration.

As TNF- $\beta$  (also known as lymphotoxin) has close structural homology with TNF- $\alpha$  (also known as cachectin) and since each induces similar biologic responses and binds to the same cellular receptor, both TNF- $\alpha$  and TNF- $\beta$  are 25 inhibited by the compounds of the present invention and thus are herein referred to collectively as "TNF" unless specifically delineated otherwise.

30 In order to use a compound of Formula (I) or a pharmaceutically acceptable salt thereof in therapy, it will normally be formulated into a pharmaceutical composition in accordance with standard pharmaceutical practice. This invention, therefore, also relates to a pharmaceutical composition

comprising an effective, non-toxic amount of a compound of Formula (I) and a pharmaceutically acceptable carrier or diluent.

Compounds of Formula (I), pharmaceutically acceptable salts thereof and pharmaceutical compositions incorporating such may conveniently be  
5 administered by any of the routes conventionally used for drug administration, for instance, orally, topically, parenterally or by inhalation. The compounds of Formula (I) may be administered in conventional dosage forms prepared by combining a compound of Formula (I) with standard pharmaceutical carriers according to conventional procedures. The compounds of Formula (I) may also  
10 be administered in conventional dosages in combination with a known, second therapeutically active compound. These procedures may involve mixing, granulating and compressing or dissolving the ingredients as appropriate to the desired preparation. It will be appreciated that the form and character of the pharmaceutically acceptable character or diluent is dictated by the amount of  
15 active ingredient with which it is to be combined, the route of administration and other well-known variables. The carrier(s) must be "acceptable" in the sense of being compatible with the other ingredients of the Formulation and not deleterious to the recipient thereof.

The pharmaceutical carrier employed may be, for example, either a solid  
20 or liquid. Exemplary of solid carriers are lactose, terra alba, sucrose, talc, gelatin, agar, pectin, acacia, magnesium stearate, stearic acid and the like. Exemplary of liquid carriers are syrup, peanut oil, olive oil, water and the like. Similarly, the carrier or diluent may include time delay material well known to the art, such as glyceryl mono-stearate or glyceryl distearate alone or with a  
25 wax.

A wide variety of pharmaceutical forms can be employed. Thus, if a solid carrier is used, the preparation can be tableted, placed in a hard gelatin capsule in powder or pellet form or in the form of a troche or lozenge. The amount of solid carrier will vary widely but preferably will be from about  
30 25mg. to about 1g. When a liquid carrier is used, the preparation will be in the

form of a syrup, emulsion, soft gelatin capsule, sterile injectable liquid such as an ampule or nonaqueous liquid suspension.

Compounds of Formula (I) may be administered topically, that is by non-systemic administration. This includes the application of a compound of 5 Formula (I) externally to the epidermis or the buccal cavity and the instillation of such a compound into the ear, eye and nose, such that the compound does not significantly enter the blood stream. In contrast, systemic administration refers to oral, intravenous, intraperitoneal and intramuscular administration.

Formulations suitable for topical administration include liquid or semi-  
10 liquid preparations suitable for penetration through the skin to the site of inflammation such as liniments, lotions, creams, ointments or pastes, and drops suitable for administration to the eye, ear or nose. The active ingredient may comprise, for topical administration, from 0.001% to 10% w/w, for instance from 1% to 2% by weight of the Formulation. It may however comprise as  
15 much as 10% w/w but preferably will comprise less than 5% w/w, more preferably from 0.1% to 1% w/w of the Formulation.

Lotions according to the present invention include those suitable for application to the skin or eye. An eye lotion may comprise a sterile aqueous solution optionally containing a bactericide and may be prepared by methods  
20 similar to those for the preparation of drops. Lotions or liniments for application to the skin may also include an agent to hasten drying and to cool the skin, such as an alcohol or acetone, and/or a moisturizer such as glycerol or an oil such as castor oil or arachis oil.

Creams, ointments or pastes according to the present invention are semi-  
25 solid formulations of the active ingredient for external application. They may be made by mixing the active ingredient in finely-divided or powdered form, alone or in solution or suspension in an aqueous or non-aqueous fluid, with the aid of suitable machinery, with a greasy or non-greasy base. The base may comprise hydrocarbons such as hard, soft or liquid paraffin, glycerol, beeswax,  
30 a metallic soap; a mucilage; an oil of natural origin such as almond, corn, arachis, castor or olive oil; wool fat or its derivatives or a fatty acid such as

stearic or oleic acid together with an alcohol such as propylene glycol or a macrogel. The formulation may incorporate any suitable surface active agent such as an anionic, cationic or non-ionic surfactant such as a sorbitan ester or a polyoxyethylene derivative thereof. Suspending agents such as natural gums, 5 cellulose derivatives or inorganic materials such as siliceous silicas, and other ingredients such as lanolin, may also be included.

Drops according to the present invention may comprise sterile aqueous or oily solutions or suspensions and may be prepared by dissolving the active ingredient in a suitable aqueous solution of a bactericidal and/or fungicidal 10 agent and/or any other suitable preservative, and preferably including a surface active agent. The resulting solution may then be clarified by filtration, transferred to a suitable container which is then sealed and sterilized by autoclaving or maintaining at 98-100° C. for half an hour. Alternatively, the solution may be sterilized by filtration and transferred to the container by an 15 aseptic technique. Examples of bactericidal and fungicidal agents suitable for inclusion in the drops are phenylmercuric nitrate or acetate (0.002%), benzalkonium chloride (0.01%) and chlorhexidine acetate (0.01%). Suitable solvents for the preparation of an oily solution include glycerol, diluted alcohol and propylene glycol.

20 Compounds of formula (I) may be administered parenterally, that is by intravenous, intramuscular, subcutaneous intranasal, intrarectal, intravaginal or intraperitoneal administration. The subcutaneous and intramuscular forms of parental administration are generally preferred. Appropriate dosage forms for such administration may be prepared by conventional techniques. Compounds 25 of Formula (I) may also be administered by inhalation, that is by intranasal and oral inhalation administration. Appropriate dosage forms for such administration, such as an aerosol formulation or a metered dose inhaler, may be prepared by conventional techniques.

For all methods of use disclosed herein for the compounds of Formula 30 (I), the daily oral dosage regimen will preferably be from about 0.01 to about 80 mg/kg of total body weight, preferably from about 0.1 to 30 mg/kg, more

preferably from about 0.2 mg to 15 mg. The daily parenteral dosage regimen about 0.01 to about 80 mg/kg of total body weight, preferably from about 0.1 to about 30 mg/kg, and more preferably from about 0.2 mg to 15mg/kg. The daily topical dosage regimen will preferably be from 0.1 mg to 150 mg, administered 5 one to four, preferably two or three times daily. The daily inhalation dosage regimen will preferably be from about 0.01 mg/kg to about 1 mg/kg per day. It will also be recognized by one of skill in the art that the optimal quantity and spacing of individual dosages of a compound of Formula (I) or a pharmaceutically acceptable salt thereof will be determined by the nature and 10 extent of the condition being treated, the form, route and site of administration, and the particular patient being treated, and that such optimums can be determined by conventional techniques. It will also be appreciated by one of skill in the art that the optimal course of treatment, i.e., the number of doses of a compound of Formula (I) or a pharmaceutically acceptable salt thereof given 15 per day for a defined number of days, can be ascertained by those skilled in the art using conventional course of treatment determination tests.

The novel compounds of Formula (I) may also be used in association with the veterinary treatment of mammals, other than humans, in need of inhibition of cytokine inhibition or production. In particular, cytokine mediated 20 diseases for treatment, therapeutically or prophylactically, in animals include disease states such as those noted herein in the Methods of Treatment section, but in particular viral infections. Examples of such viruses include, but are not limited to, lentivirus infections such as, equine infectious anaemia virus, caprine arthritis virus, visna virus, or maedi virus or retrovirus infections, such as but 25 not limited to feline immunodeficiency virus (FIV), bovine immunodeficiency virus, or canine immunodeficiency virus or other retroviral infections.

The invention will now be described by reference to the following biological examples which are merely illustrative and are not to be construed as a limitation of the scope of the present invention.

#### BIOLOGICAL EXAMPLES

The cytokine-inhibiting effects of compounds of the present invention were determined by the following *in vitro* assays:

**Interleukin - 1 (IL-1)**

Human peripheral blood monocytes are isolated and purified from either  
5 fresh blood preparations from volunteer donors, or from blood bank buffy coats,  
according to the procedure of Colotta *et al.*, J Immunol, 132, 936 (1984). These  
monocytes ( $1 \times 10^6$ ) are plated in 24-well plates at a concentration of 1-2  
million/ml per well. The cells are allowed to adhere for 2 hours, after which  
time non-adherent cells are removed by gentle washing. Test compounds are  
10 then added to the cells for 1h before the addition of lipopolysaccharide (50  
ng/ml), and the cultures are incubated at 37°C for an additional 24h. At the end  
of this period, culture supernatants are removed and clarified of cells and all  
debris. Culture supernatants are then immediately assayed for IL-1 biological  
activity, either by the method of Simon *et al.*, J. Immunol. Methods, 84, 85,  
15 (1985) (based on ability of IL-1 to stimulate a Interleukin 2 producing cell line  
(EL-4) to secrete IL-2, in concert with A23187 ionophore) or the method of Lee  
*et al.*, J. ImmunoTherapy, 6 (1), 1-12 (1990) (ELISA assay).

**Tumour Necrosis Factor (TNF):**

20 Human peripheral blood monocytes are isolated and purified from either  
blood bank buffy coats or platelet pheresis residues, according to the procedure  
of Colotta, R. *et al.*, J Immunol, 132(2), 936 (1984). The monocytes are plated  
at a density of  $1 \times 10^6$  cells/ml medium/well in 24-well multi-dishes. The cells  
are allowed to adhere for 1 hour after which time the supernatant is aspirated  
25 and fresh medium (1ml, RPMI-1640, Whitaker Biomedical Products, Whitaker,  
CA) containing 1% fetal calf serum plus penicillin and streptomycin (10  
units/ml) added. The cells are incubated for 45 minutes in the presence or  
absence of a test compound at 1nM-10mM dose ranges (compounds are  
solubilized in dimethyl sulfoxide/ethanol, such that the final solvent  
30 concentration in the culture medium is 0.5% dimethyl sulfoxide/0.5% ethanol).  
Bacterial lipopolysaccharide (*E. coli* 055:B5 [LPS] from Sigma Chemicals Co.)

is then added (100 ng/ml in 10 ml phosphate buffered saline) and cultures incubated for 16-18 hours at 37°C in a 5% CO<sub>2</sub> incubator. At the end of the incubation period, culture supernatants are removed from the cells, centrifuged at 3000 rpm to remove cell debris. The supernatant is then assayed for TNF activity using either a radio-immuno or an ELISA assay, as described in WO 5 92/10190 and by Becker *et al.*, J Immunol, 1991, 147, 4307.

IL-1 and TNF inhibitory activity does not seem to correlate with the property of the compounds of Formula (I) in mediating arachidonic acid 10 metabolism inhibition. Further the ability to inhibit production of prostaglandin and/or leukotriene synthesis, by nonsteroidal anti-inflammatory drugs with potent cyclooxygenase and/or lipoxygenase inhibitory activity does not mean that the compound will necessarily also inhibit TNF or IL-1 production, at non-toxic doses.

15

**Interleukin -8 (IL-8):**

Primary human umbilical cord endothelial cells (HUVEC) (Cell Systems, Kirland, Wa) are maintained in culture medium supplemented with 15% fetal bovine serum and 1% CS-HBGF consisting of aFGF and heparin. 20 The cells are then diluted 20-fold before being plated (250µl) into gelating coated 96-well plates. Prior to use, culture medium are replaced with fresh medium (200µl). Buffer or test compound (25µl, at concentrations between 1 and 10µM) is then added to each well in quadruplicate wells and the plates incubated for 6h in a humidified incubator at 37°C in an atmosphere of 5% 25 CO<sub>2</sub>. At the end of the incubation period, supernatant is removed and assayed for IL-8 concentration using an IL-8 ELISA kit obtained from R&D Systems (Minneapolis, MN). All data is presented as mean value (ng/ml) of multiple samples based on the standard curve. IC<sub>50</sub>'s where appropriate are generated by non-linear regression analysis.

30

**Cytokine Specific Binding Protein Assay**

A radiocompetitive binding assay was developed to provide a highly reproducible primary screen for structure-activity studies. This assay provides many advantages over the conventional bioassays which utilize freshly isolated

5    human monocytes as a source of cytokines and ELISA assays to quantify them. Besides being a much more facile assay, the binding assay has been extensively validated to highly correlate with the results of the bioassay. A specific and reproducible cytokine inhibitor binding assay was developed using soluble cytosolic fraction from THP.1 cells and a radiolabeled compound. Patent

10   Application USSN 08/123175 Lee et al., filed September 1993, USSN; Lee et al., PCT 94/10529 filed 16 September 1994 and Lee et al., *Nature* 300, n(72), 739-746 (Dec. 1994) whose disclosures are incorporated by reference herein in its entirety describes the above noted method for screening drugs to identify compounds which interact with and bind to the cytokine specific binding

15   protein (hereinafter CSBP). However, for purposes herein the binding protein may be in isolated form in solution, or in immobilized form, or may be genetically engineered to be expressed on the surface of recombinant host cells such as in phage display system or as fusion proteins. Alternatively, whole cells or cytosolic fractions comprising the CSBP may be employed in the screening

20   protocol. Regardless of the form of the binding protein, a plurality of compounds are contacted with the binding protein under conditions sufficient to form a compound/ binding protein complex and compound capable of forming, enhancing or interfering with said complexes are detected.

Representative compounds of Formula (I), Examples 1 to 24, have all

25   demonstrated positive inhibitory activity in this binding assay.

**Prostaglandin end peroxide synthase-2 (PGHS-2) assay:**

The following assay describes a method for determining the inhibitory effects of compounds of Formula (I) on human PGHS-2 protein expression in LPS stimulated human monocytes. The assay shown below is demonstrated  
5 with compounds other than that of Formula (I) herein:

Method: Human peripheral blood monocytes were isolated from buffy coats by centrifugation through Ficoll and Percoll gradients. Cells were seeded at 2 X 10<sup>6</sup>/well in 24 well plates and allowed to adhere for 1 hour in RPMI supplemented with 1% human AB serum, 20mM L-glutamine, Penicillin-  
10 Streptomycin and 10mM HEPES. Compounds were added at various concentrations and incubated at 37°C for 10 minutes. LPS was added at 50 ng/well (to induce enzyme expression) and incubated overnight at 37°C. The supernatant was removed and cells washed once in cold PBS. The cells were lysed in 100ml of cold lysis buffer(50mM Tris/HCl pH 7.5, 150mM NaCl, 1%  
15 NP40, 0.5% sodium deoxycholate, 0.1% SDS, 300ug/ml DNase, 0.1% TRITON X-100, 1mM PMSF, 1mM leupeptin, 1mM pepstatin). The lysate was centrifuged (10,000 X g for 10 min. at 4°C) to remove debris and the soluble fraction was subjected to SDS PAGE analysis (12% gel). Protein separated on the gel were transferred onto nitrocellulose membrane by electrophoretic means  
20 for 2 hours at 60 volts. The membrane was pretreated for one hour in PBS/0.1% Tween 20 with 5% non-fat dry milk. After washing 3 times in PBS/Tween buffer, the membrane was incubated with a 1:2000 dilution of a monospecific antiserum to PGHS-2 or a 1:1000 dilution of an antiserum to PGHs-1 in PBS/Tween with 1% BSA for one hour with continuous shaking.  
25 The membrane was washed 3X in PBS/Tween and then incubated with a 1:3000 dilution of horseradish peroxidase conjugated donkey antiserum to rabbit Ig (Amersham) in PBS/Tween with 1% BSA for one hour with continuous shaking. The membrane was then washed 3X in PBS/Tween and the ECL immunodetection system (Amersham) was used to detect the level of expression  
30 of prostaglandin endoperoxide synthases-2.

Results: The following compounds were tested and found to be active in this assay (i.e., inhibited LPS induced PGHS-2 protein expression in rank order potency similar to that for inhibiting cytokine production as noted in assays indicated): 6-(4-Fluoro-phenyl)-2,3-dihydro-5-(4-pyridinyl)imidazo[2,1-  
5 b]thiazole; and Dexamethasone

Several compounds were tested and found to be inactive (up to 10uM): 2-(4-Methylsulfinylphenyl)-3-(4-pyridyl)-6,7-dihydro-(5H)-pyrrolo[1,2-a]imidazole; rolipram ; phenidone and NDGA. None of these compounds tested were found to inhibit PGHS-1 or cPLA<sub>2</sub> protein levels in similar  
10 experiments.

#### TNF- $\alpha$ in Traumatic Brain Injury Assay

The present assay provides for examination of the expression of tumor necrosis factor mRNA in specific brain regions which follow experimentally induced lateral fluid-percussion traumatic brain injury (TBI) in rats. Adult Sprague-Dawley rats (n=42) are anesthetized with sodium pentobarbital (60 mg/kg, i.p.) and subjected to lateral fluid-percussion brain injury of moderate severity (2.4 atm.) centered over the left temporoparietal cortex (n=18), or "sham" treatment (anesthesia and surgery without injury, n=18). Animals are sacrificed by decapitation at 1, 6 and 24 hr. post injury, brains removed, and tissue samples of left (injured) parietal cortex (LC), corresponding area in the contralateral right cortex (RC), cortex adjacent to injured parietal cortex (LA), corresponding adjacent area in the right cortex (RA), left hippocampus (LH) and right hippocampus (RH) are prepared. Total RNA is isolated and Northern blot hybridization is performed and quantitated relative to an TNF- $\alpha$  positive control RNA (macrophage = 100%). A marked increase of TNF- $\alpha$  mRNA expression is observed in LH (104±17% of positive control, p < 0.05 compared with sham), LC (105±21%, p < 0.05) and LA (69±8%, p < 0.01) in the traumatized hemisphere 1 hr. following injury. An increased TNF- $\alpha$  mRNA expression is also observed in LH (46±8%, p < 0.05), LC (30±3%, p < 0.01) and LA (32±3%, p < 0.01) at 6 hr. which resolves by 24 hr. following injury. In  
15  
20  
25  
30

the contralateral hemisphere, expression of TNF- $\alpha$  mRNA is increased in RH ( $46\pm2\%$ ,  $p < 0.01$ ), RC ( $4\pm3\%$ ) and RA ( $22\pm8\%$ ) at 1 hr. and in RH ( $28\pm11\%$ ), RC ( $7\pm5\%$ ) and RA ( $26\pm6\%$ ,  $p < 0.05$ ) at 6 hr. but not at 24 hr. following injury. In sham (surgery without injury) or naive animals, no consistent changes in expression of TNF- $\alpha$  mRNA is observed in any of the 6 brain areas in either hemisphere at any times. These results indicate that following parasagittal fluid-percussion brain injury, the temporal expression of TNF- $\alpha$  mRNA is altered in specific brain regions, including those of the non-traumatized hemisphere. Since TNF- $\alpha$  is able to induce nerve growth factor (NGF) and stimulate the release of other cytokines from activated astrocytes, this post-traumatic alteration in gene expression of TNF- $\alpha$  plays an important role in both the acute and regenerative response to CNS trauma.

#### CNS Injury model for IL- $\beta$ mRNA

This assay characterizes the regional expression of interleukin-1 $\beta$  (IL-1 $\beta$ ) mRNA in specific brain regions following experimental lateral fluid-percussion traumatic brain injury (TBI) in rats. Adult Sprague-Dawley rats ( $n=42$ ) are anesthetized with sodium pentobarbital (60 mg/kg, i.p.) and subjected to lateral fluid-percussion brain injury of moderate severity (2.4 atm.) centered over the left temporoparietal cortex ( $n=18$ ), or "sham" treatment (anesthesia and surgery without injury). Animals are sacrificed at 1, 6 and 24 hr. post injury, brains removed, and tissue samples of left (injured) parietal cortex (LC), corresponding area in the contralateral right cortex (RC), cortex adjacent to injured parietal cortex (LA), corresponding adjacent area in the right cortex (RA), left hippocampus (LH) and right hippocampus (RH) were prepared. Total RNA is isolated and Northern blot hybridization is performed and the quantity of brain tissue IL-1 $\beta$  mRNA is presented as percent relative radioactivity of IL-1 $\beta$  positive macrophage RNA which is loaded on same gel. At 1 hr. following brain injury, a marked and significant increase in expression of IL-1 $\beta$  mRNA is observed in LC ( $20.0\pm0.7\%$  of positive control,  $n=6$ ,  $p < 0.05$  compared with sham animal), LH ( $24.5\pm0.9\%$ ,  $p < 0.05$ ) and LA

(21.5±3.1%, p < 0.05) in the injured hemisphere, which remained elevated up to 6 hr. post injury in the LC (4.0±0.4%, n=6, p < 0.05) and LH (5.0±1.3%, p < 0.05). In sham or naive animals, no expression of IL-1 $\beta$  mRNA is observed in any of the respective brain areas. These results indicate that following TBI,  
5 the temporal expression of IL-1 $\beta$  mRNA is regionally stimulated in specific brain regions. These regional changes in cytokines, such as IL-1 $\beta$  play a role in the post-traumatic pathologic or regenerative sequelae of brain injury.

## SYNTHETIC EXAMPLES

10 The invention will now be described by reference to the following examples which are merely illustrative and are not to be construed as a limitation of the scope of the present invention. All temperatures are given in degrees centigrade, all solvents are highest available purity and all reactions run under anhydrous conditions in an argon atmosphere unless otherwise indicated.

15 In the Examples, all temperatures are in degrees Centigrade (°C). Mass spectra were performed upon a VG Zab mass spectrometer using fast atom bombardment, unless otherwise indicated.  $^1\text{H-NMR}$  (hereinafter "NMR") spectra were recorded at 250 MHz using a Bruker AM 250 or Am 400 spectrometer. Multiplicities indicated are: s=singlet, d=doublet, t=triplet, q=quartet, m=multiplet and br indicates a broad signal. Sat. indicates a saturated solution, eq indicates the proportion of a molar equivalent of reagent relative to the principal reactant.  
20 Flash Chromatography is run over a Merck Silica gel 60 (230-400 mesh).

25 Example 1

### 1-(1H-Indol-3-ylcarbonyl)-4-(benzyl)piperazine

Indole-3-carboxylic acid (161 mg, 1.0 mmol), benzyl piperazine (347  $\mu\text{L}$ , 2.0 mmol), triethylamine (278  $\mu\text{L}$ , 2.0 mmol), and  $\text{CH}_2\text{Cl}_2$  (4 mL), were combined and  $\text{SOCl}_2$  (146  $\mu\text{L}$ , 2.0 mmol) in  $\text{CH}_2\text{Cl}_2$  (4 mL) was added  
30 dropwise. The resulting mixture was stirred at 23° for 40 min, diluted with  $\text{CH}_2\text{Cl}_2$  (75 mL), washed with 10% aq NaOH (20 mL), combined with flash

silica (40 mL) and the slurry was added to more flash silica in a sintered glass funnel and eluted with 0 - 2% CH<sub>3</sub>OH in CH<sub>2</sub>Cl<sub>2</sub> to afford 297 mg (95%) as a white solid. ES+ MS m/z = 320 (MH<sup>+</sup>).

5

Example 21-(1H-Indol-3-ylcarbonyl)-4-(phenyl)piperazine

By the procedure of example 1 except using phenyl piperazine afforded the title compound as a white solid. ES+ MS m/z = 306 (MH<sup>+</sup>).

10

Example 31-(1H-Indol-3-ylcarbonyl)-4-(2-pyridinyl)piperazine

By the procedure of example 1 except using 2-pyridyl piperazine afforded the title compound as a white solid. ES+ MS m/z = 307 (MH<sup>+</sup>).

15

Example 41-(1H-Indol-3-ylcarbonyl)-4-(2-pyrimidinyl)piperazine

By the procedure of example 1 except using 2-pyrimidinyl piperazine afforded the title compound as a white solid. ES+ MS m/z = 308 (MH<sup>+</sup>).

20

Example 51-(1H-Indol-3-ylcarbonyl)-4-(diphenylmethyl)piperazine

By the procedure of example 1 except using diphenylmethyl piperazine afforded the title compound as a white solid. ES+ MS m/z = 396 (MH<sup>+</sup>).

Example 61-(1H-Indol-3-ylcarbonyl)-4-(4-pyridinylmethyl)piperazine

By the procedure of example 1 except using 4-pyridylmethyl piperazine afforded the title compound as a white solid. ES+ MS m/z = 321 (MH+).

5

Example 71-(1H-Indol-3-ylcarbonyl)-4-(4-trifluoromethylphenylmethyl)piperazinea) -1-Tertbutoxycarbonyl-4-(4-trifluoromethylbenzyl) piperazine

To a solution of 4-tert butoxycarbonyl piperazine (250 mg) in acetone (5 ml) was added potassium carbonate (185 mg) and  $\alpha$ -bromomethyl-4-trifluoromethyl benzene (320 mg). The mixture was heated to reflux overnight. After cooling the solvent was concentrated and the residue partitioned between chloroform and water. The organic phase was dried ( $\text{Na}_2\text{SO}_4$ ), filtered and concentrated to afford the title compound as an oil (460 mg).  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ) d : 1.48 (s, 9H), 2.40 (t, 4H), 3.45 (t, 4H), 3.57 (s, 2H), 7.45 (d, 2H), 7.59 (d, 2H).

b) 1-(4-Trifluoromethylbenzyl) piperazine

To the product of the previous example (460 mg) in dichloromethane (5 ml) was added dropwise trifluoroacetic acid (1 ml). Stirring was continued under an inert atmosphere for 1 h. The solvent was concentrated *in vacuo*, using toluene to azeotrope final traces of TFA. The intermediate triflate salt was dissolved in water (5 ml) and basified by addition of solid potassium carbonate. The free base was extracted into dichloromethane. The organic phase was dried ( $\text{Na}_2\text{SO}_4$ ) and concentrated to afford the title compound (320 mg) as an oil.

$^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ) d : 2.36-2.49 (m, 4H), 2.92 (t, 4H), 3.54 (s, 2H), 7.45 (d, 2H), 7.59 (d, 2H)

c) 1-(1H-Indol-3-ylcarbonyl)-4-(4-trifluoromethylbenzyl)piperazine SB-223877

30 By the procedure of example 1 except using 1-(4-trifluoromethylbenzyl) piperazine afforded the title compound  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ) d : 2.48

(t, 4H), 3.60 (s, 2H), 3.69 - 3.80 (m, 4H), 7.18 - 7.22 (m, 2H), 7.26 - 7.34 (m, 2H), 7.45 (d, 2H), 7.68 (d, 2H), 7.70 (dd, 1H) 9.28 (bs, 1H).

#### Example 8

5    1-(1H-Indol-3-ylcarbonyl)-4-(4-fluorophenylmethyl)piperazine

The title compound was prepared according to the general method of Example 7.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ) d : 2.45 (t, 4H), 3.50 (s, 2H), 3.73 (t, 4H), 6.99 (t, 2H), 7.15-7.48 (m, 6H), 7.66-7.72 (m, 1H), 9.09 (bs, 1H).

10

#### Example 9

1-(1H-Indol-3-ylcarbonyl)-4-(methyl)piperazine

The title compound was prepared according to the general method of Example 7.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ) d : 2.38 (s, 3H), 2.49 (t, 4H), 3.78 (t, 4H), 7.17-7.25 (m, 2H), 7.31-7.37 (m, 2H), 7.68 - 7.73 (m, 1H), 9.25 (bs, 1H).

15

#### Example 10

1-(1H-Indol-3-ylcarbonyl)-4-(cyclohexyl)piperazine

The title compound was prepared according to the general method of Example 7.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ) d : 1.09 - 1.32 (m, 5H), 1.78 - 1.91 (m, 4H), 2.25 - 2.35 (m, 1H), 2.61 (t, 4H), 3.71 (t, 4H), 7.18-7.26 (m, 2H), 7.37 - 7.41 (m, 1H), 7.49 (d, 1H), 7.67-7.72 (m, 1H), 8.72 (bs, 1H).

20

#### Example 11

1-(1H-Indol-3-ylcarbonyl)-4-(cyclopropylmethyl)piperazine

The title compound was prepared according to the general method of Example 7. M. S. :(CI) ;  $\text{MH}^+ 284$

25

#### Example 12

1-(1H-Indol-3-ylcarbonyl)-4-(4-methylbenzyl)piperazine

The title compound was prepared according to the general method of Example 7.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ) d : 2.35 (s, 3H), 2.41 - 2.52 (m, 4H),

3.52 (s, 2H), 3.67 - 3.78 (m, 4H), 7.10-7.31 (m, 8H), 7.65 - 7.72 (m, 1H), 9.41 (bs, 1H).

### Example 13

5    1-(1H-Indol-3-ylcarbonyl)-4-(4-cyanobenzyl)piperazine

The title compound was prepared according to the general method of Example 7.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ) d : 2.41 - 2.53 (m, 4H), 3.60 (s, 2H), 3.70 - 3.79 (m, 4H), 7.17-7.39 (m, 4H), 7.46 (d, 2H), 7.62 (d, 2H), 7.66-7.72 (m, 1H), 9.22 (bs, 1H).

10

### Example 14

1-(1H-Indol-3-ylcarbonyl)-4-(2-naphthyl)piperazine

The title compound was prepared according to the general method of Example 7.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ) d : 2.50 - 2.59 (m, 4H), 3.61 (s, 2H),  
15    3.62 - 3.73 (m, 4H), 7.14 - 7.21 (m, 2H), 7.34-7.39 (m, 2H), 7.44-7.54 (m, 3H),  
7.68 - 7.86 (m, 5H), 9.74 (bs, 1H).

### Example 15

1-(1H-Indol-3-ylcarbonyl)-4-(2-phenylethyl)piperazine

20    The title compound was prepared according to the general method of Example 7.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ) d : 2.44 - 2.70 (m, 6H), 2.78 - 2.88 (m, 2H), 3.67 - 3.82 (m, 4H), 7.12-7.43 (m, 8H), 7.65-7.72 (m, 1H), 9.49 (bs, 1H).

### Example 16

25    1-(1H-Indol-3-ylcarbonyl)-4-(4-methoxybenzyl)piperazine

The title compound was prepared according to the general method of Example 7.  $^1\text{H}$  NMR (250 MHz,  $\text{CDCl}_3$ ) d : 2.45 - 2.53 (m, 4H), 3.51 (s, 2H), 3.70 - 3.76 (m, 4H), 3.81(s,3H), 6.86 (d, 2H), 7.18-7.29 (m, 4H), 7.37-7.41 (m, 2H), 7.66 - 7.72 (m, 1H), 9.59 (bs, 1H).

30

### Example 17

1-(1H-5-Bromoindol-3-ylcarbonyl)-4-(benzyl)piperazine

a) 1H-3-Trifluoroacetyl-5-bromoindole

5-Bromoindole (0.98 g, 5.0 mmol) and THF (3.0 mL) were combined and the resulting solution was cooled to 4°, and TFAA (1.26 g, 6.0 mmol) was added dropwise, stirred for 16 h, poured into H<sub>2</sub>O, filtered, washed, with H<sub>2</sub>O, dried in vacuo to afford the title compound. ES- MS m/z = 290 (M - H)<sup>-</sup>.

5

b) 1H-3-Carboxy-5-bromoindole

The product of the previous example was combined with 20% aq NaOH and heated to reflux for 15 min. Cooled to 23°, washed with EtOAc and then acidified with concentrated HCl to < pH 1. The resulting precipitate was 10 filtered, dried *in vacuo* to afford 0.79 g (66% from 5-bromoindole). ES- MS m/z = 238 (M - H)<sup>-</sup>.

10

c) 1-(1H-5-Bromoindol-3-ylcarbonyl)-4-(benzyl)piperazine SB-241938

The product of the previous example was reacted by the method of example 1 to afford the title compound. ES+ MS m/z = 398 (MH<sup>+</sup>).

15

Example 18

1-(1H-5-Methylindol-3-ylcarbonyl)-4-(benzyl)piperazine

5-Methylindole was converted to the title compound according to the general method of example 17. ES+ MS m/z = 333 (MH<sup>+</sup>).

20

Example 19

1-(1H-5-Chloroindol-3-ylcarbonyl)-4-(benzyl)piperazine

5-Chloroindole was converted to the title compound according to the general method of example 17. ES+ MS m/z = 354 (MH<sup>+</sup>).

25

Example 20

1-(1H-5-Benzylxyindol-3-ylcarbonyl)-4-(benzyl)piperazine

5-Benzylxyindole was converted to the title compound according to the general method of example 17. ES+ MS m/z = 426 (MH<sup>+</sup>).

30

Example 21

1-(1H-5-Nitroindol-3-ylcarbonyl)-4-(benzyl)piperazine

5-Nitroindole was converted to the title compound according to the general method of example 17. ES+ MS m/z = 365 (MH+).

#### Example 22

5 1-(1H-5-Fluoroindol-3-ylcarbonyl)-4-(benzyl)piperazine

5-Fluoroindole was converted to the title compound according to the general method of example 17. ES+ MS m/z = 338 (MH+).

#### Example 23

10 1-(1H-5-Aminoindol-3-ylcarbonyl)-4-(benzyl)piperazine

The product of example 21 (91 mg, 0.25 mmol) CH<sub>3</sub>OH (15 mL), HOAC (100 mL) and PtO(10 mg) were combined and shaken in a Parr apparatus at 50 psi H<sub>2</sub> for 2 h. The mixture was filtered through a pad of celite. The filtrate was concentrated and the residue was fractionally crystallized from Et<sub>2</sub>O to afford 25 mg of the title compound as an off white solid. ES+ MS m/z = 335 (MH+).

#### Example 24

1-(1H-5-Phenylindol-3-ylcarbonyl)-4-(benzyl)piperazine

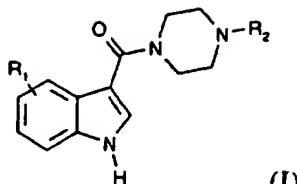
20 The product of example 17 (200 mg, 0.5 mmol), phenylboronic acid (242 mg, 2.0 mmol), Pd(PPh<sub>3</sub>)<sub>4</sub> (20 mg), dimethoxyethane (5 mL) and 2M aq Na<sub>2</sub>CO<sub>3</sub> (1 mL) were combined under Ar and the solvent was refluxed for 6 h, and stored at 2° for 2 days. The reaction was treated with 30% H<sub>2</sub>O<sub>2</sub> (0.5 mL) and stirred 30 min. Diluted the mixture with CH<sub>2</sub>Cl<sub>2</sub> (100 mL) washed 25 with 10% aq NaOH, and filtered through a plug of silica (100mL) with 0-4% MeOH in CH<sub>2</sub>Cl<sub>2</sub> to afford 158 mg (80%). ES+ MS m/z = 396 (MH+).

The above description fully discloses the invention including preferred embodiments thereof. Modifications and improvements of the embodiments 30 specifically disclosed herein are within the scope of the following claims. Without further elaboration, it is believed that one skilled in the art can, using

the preceding description, utilize the present invention to its fullest extent. Therefore the Examples herein are to be construed as merely illustrative and not a limitation of the scope of the present invention in any way. The embodiments of the invention in which an exclusive property or privilege is claimed are  
5 defined as follows.

## WHAT IS CLAIMED IS:

## 1. A compound of the formula:



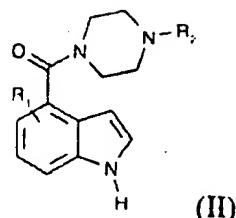
5

wherein

- R<sub>1</sub> is hydrogen, alkyl, aryl, heteroaryl, aryloxy, heteroaryloxy, nitro, amino, cyano, carboxy, carboxyalkoxy, carboxamido, or halogen, wherein the aryl, heteroaryl, heteroaryloxy, or aryloxy moieties may be optionally substituted; and
- 10 R<sub>2</sub> is aryl, heteroaryl, arylalkyl, heteroarylalkyl, alkyl, cycloalkyl, or cycloalkyl alkyl, and wherein all of these moieties may be optionally substituted; or a pharmaceutically acceptable salt thereof.
  
- 2. The compound according to Claim 1 wherein R<sub>1</sub> is hydrogen, halogen, methyl, phenyl, benzyloxy, nitro, or amino.
  
- 3. The compound according to Claim 1 wherein R<sub>2</sub> is benzyl, phenyl, pyridyl, pyrimidinyl diphenylmethyl, pyridylmethyl, benzyl, alkyl, cyclohexyl, or naphthylmethyl, or phenylethyl.
  
- 20 4. The compound according to Claim 3 wherein R<sub>2</sub> is benzyl, or benzyl substituted by haloalkyl, alkyl, halogen, cyano, or alkoxy.
  
- 5. The compound according to Claim 3 wherein R<sub>2</sub> is phenyl, or phenyl substituted by halogen, haloalkyl, alkoxy, or alkyl.
  
- 25 6. A pharmaceutical composition comprising a compound according to any of Claims 1 to 5 and a pharmaceutically acceptable carrier or diluent.

7. A method of treating inflammation in a mammal in need thereof, which comprises administering to said mammal an effective amount of a compound of Formula (I) according to any of Claims 1 to 5.
  
- 5 8. A method of treating osteoporosis in a mammal in need thereof, which comprises administering to said mammal an effective amount of a compound of Formula (I) according to any of Claims 1 to 5.
  
9. A method of inhibiting the synthesis of prostaglandin endoperoxide  
10 synthase-2 (PGHS-2) in a mammal in need thereof, which comprises  
administering to said mammal an effective amount of a compound of Formula  
(I) according to any of Claims 1 to 5.
  
10. The method according to Claim 13 wherein inhibition of PGHS-2 is  
15 used in the prophylaxis or therapeutic treatment of edema, fever, algesia,  
neuromuscular pain, headache, cancer pain, or arthritic pain.
  
11. A method of treating a CSBP/RK/p38 kinase mediated disease, in a  
mammal in need thereof, which comprises administering to said mammal an  
20 effective amount of a compound of Formula (I) according to any one of Claims  
1 to 5.
  
12. The method according to claim 11 wherein the mammal is afflicted with  
a CSBP/RK/p38 kinase mediated disease which is cytokine mediated and the  
25 disease is selected from rheumatoid arthritis, rheumatoid spondylitis,  
osteoarthritis, gouty arthritis and other arthritic conditions, sepsis, septic shock,  
endotoxic shock, gram negative sepsis, toxic shock syndrome, asthma, adult  
respiratory distress syndrome, stroke, cerebral malaria, chronic pulmonary  
inflammatory disease, silicosis, pulmonary sarcososis, bone resorption diseases,  
30 osteoporosis, reperfusion injury, graft vs. host reaction, allograft rejections,  
Crohn's disease, ulcerative colitis or pyresis.

## 13. A compound of the formula:



5 wherein

R<sub>1</sub> is hydrogen, alkyl, aryl, heteroaryl, aryloxy, heteroaryloxy, nitro, amino, cyano, carboxy, carboxyalkoxy, carboxamido, or halogen, wherein the aryl, heteroaryl, heteroaryloxy, or aryloxy moieties may be optionally substituted; and R<sub>2</sub> is aryl, heteroaryl, arylalkyl, heteroarylalkyl, alkyl, cycloalkyl, or cycloalkyl alkyl, and wherein all of these moieties may be optionally substituted; or a pharmaceutically acceptable salt thereof.

14. The compound according to Claim 13 wherein R<sub>1</sub> is hydrogen, halogen, methyl, phenyl, benzyloxy, nitro, or amino.

15

15. The compound according to Claim 13 wherein R<sub>2</sub> is benzyl, phenyl, pyridyl, pyrimidinyl diphenylmethyl, pyridylmethyl, benzyl, alkyl, cyclohexyl, or naphthylmethyl, or phenylethyl.

20

16. The compound according to Claim 15 wherein R<sub>2</sub> is benzyl, or benzyl substituted by haloalkyl, alkyl, halogen, cyano, or alkoxy.

17. The compound according to Claim 15 wherein R<sub>2</sub> is phenyl, or phenyl substituted by halogen, haloalkyl, alkoxy, or alkyl.

25

18. A pharmaceutical composition comprising a compound according to any of Claims 13 to 18 and a pharmaceutically acceptable carrier or diluent.

19. A method of treating inflammation in a mammal in need thereof, which comprises administering to said mammal an effective amount of a compound of Formula (II) according to any of Claims 13 to 18.
- 5 20. A method of treating osteoporosis in a mammal in need thereof, which comprises administering to said mammal an effective amount of a compound of Formula (II) according to any of Claims 13 to 18.
- 10 21. A method of inhibiting the synthesis of prostaglandin endoperoxide synthase-2 (PGHS-2) in a mammal in need thereof, which comprises administering to said mammal an effective amount of a compound of Formula (II) according to any of Claims 13 to 18.
- 15 22. The method according to Claim 21 wherein inhibition of PGHS-2 is used in the prophylaxis or therapeutic treatment of edema, fever, algesia, neuromuscular pain, headache, cancer pain, or arthritic pain.
- 20 23. A method of treating a CSBP/RK/p38 kinase mediated disease, in a mammal in need thereof, which comprises administering to said mammal an effective amount of a compound of Formula (II) according to any one of Claims 13 to 18.
- 25 24. The method according to Claim 23 wherein the mammal is afflicted with a CSBP/RK/p38 kinase mediated disease which is cytokine mediated and the disease is selected from rheumatoid arthritis, rheumatoid spondylitis, osteoarthritis, gouty arthritis and other arthritic conditions, sepsis, septic shock, endotoxic shock, gram negative sepsis, toxic shock syndrome, asthma, adult respiratory distress syndrome, stroke, cerebral malaria, chronic pulmonary inflammatory disease, silicosis, pulmonary sarcososis, bone resorption diseases, 30 osteoporosis, reperfusion injury, graft vs. host reaction, allograft rejections, Crohn's disease, ulcerative colitis or pyresis.

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US97/13873

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :C07D 403/06, 403/14, 401/14; A61K 31/495.  
 US CL :544/357,360,373; 514/253.

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 544/357,360,373; 514/253.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CAS ONLINE STRUCTURE SEARCH

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages  | Relevant to claim No.        |
|-----------|---|------------------------------|
| Y         | US 5,330,986 A (SHUTSKE) 19 JULY 1994, especially col.5.  | 1-6,9-10,<br>13-18,<br>21-22 |
| Y         | US 5,489,593 ( PALMER et al.) 06 FEBRUARY 1996,examples such as 10-29,35-38.  | 1-6,13-18                    |
| X         | EP 496692 A ( FABRICA ESPANOLA DE PRODUCTOS QUIMICOS Y FARMACEUTICOS, S.A.(FAES)) 29 JULY 1992,species in claim 2 on p.3. | 1-3,5-6<br>-----             |
| Y         | DE 2008692 DT (J.BOURDAIS). 17 SEPTEMBER 1970,see examples 4,12-17.   | 13-15,17-18                  |
| X         |   | 1-3,6<br>-----               |
| Y         |   | 13-15,18                     |

 Further documents are listed in the continuation of Box C.

See patent family annex.

|  |  |   |
|--|--|---|
| * Special categories of cited documents: | "T"  | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
| "A"                                      | document defining the general state of the art which is not considered to be of particular relevance   |   |
| "B"                                      | earlier document published on or after the international filing date   | "X"   |
| "C"                                      | document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "Y"   |
| "O"                                      | document referring to an oral disclosure, use, exhibition or other means   |   |
| "P"                                      | document published prior to the international filing date but later than the priority date claimed   | "A"   |
|  |  | document member of the same patent family   |

Date of the actual completion of the international search

22 SEPTEMBER 1997

Date of mailing of the international search report

12 NOV 1997

Name and mailing address of the ISA/US  
 Commissioner of Patents and Trademarks  
 Box PCT  
 Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

Emily Bernhardt

Telephone No. (703)308-1235

## INTERNATIONAL SEARCH REPORT

|   |
|---|
| International application No.<br>PCT/US97/13873 |
|---|

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No.            |
|-----------|--|----------------------------------|
| X<br>---  | ROMERO et al. "Discovery,Synthesis, and Bioactivity of Bis (heteroaryl)piperazines.I. A Novel Class of Non-Nucleoside HIV-1 Transcriptase Inhibitors", Journal of Medicinal Chemistry 01 April 1994, Vol.37,pages 999-1014,especially Table 2,no.29 and Tables 3 and 4.  | 1-3,6<br>-----                   |
| Y         |  | 5,13-15, 17-18                   |
| X         | Germain et al. "Syntheses d'indoles par cyclisation reductrice. II.(1) Nouvelle methode de synthese des indole carboxamides-3,donnant acces aux derives de la gramine", Journal of Heterocyclic Chemistry December 1976, Vol.13, pages 1209-1218,especially Table IV.  | 1-3,5-6                          |
| X<br>---  | Chemical Abstracts, Vol.116,No.5,03 February 1992 (Columbus,OH.,USA),page 763,column 1,the abstract  | 1-4,6<br>-----                   |
| Y         | No.41299m,Yanai et al. "Preparation and formulation of indolecarboxamide derivatives as central nervous agents" JP 03,161,470 11 July 1991. See piperazine derivative indexed in Vol.116 Formula Index.  | 13-16,18                         |
| Y         | Chemical Abstract, Vol.119,No.3 19 July 1993 (Columbus,OH.,USA),page 28158,column 1,the abstract no.28161c,Shibayama et al. "Preparation of piperazine or piperidine group-containing indoles and their uses as anti-inflammatory,antiallergy, and anti-PAF agents" JP 05 25,131 02 February 1993. See pierazine derivatives indexed in Vol.119 Formula Index. | 1-4,6,7,<br>9-16,18-<br>19,21-24 |